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# DISCUSSIONS

## WOOD PIPE AND WATER HAMMER

Mr. Ledoux has indeed contributed noteworthy observations[1] concerning wood pipe. It is papers of this nature which greatly assist in clearing away the skepticism regarding this type of pipe which I have found prevalent among both laymen and engineers.

There are, however, two matters pertaining to wood pipe which were not mentioned. There are instances where the staves have received a creosote treatment and it would be interesting to know the extent of the use of this treatment, together with its advantages.

Where a pipe is under constant pressure cresote treatment would hardly seem necessary or even desirable. This is in view of the fact that the manufacturers of stave pipe state that one of the essentials to the life of the pipe is that the stave shall be thoroughly saturated, so that the outside of the stave is moist. There are undoubtedly cases where partial penetration of creosote would be advantageous.

The other matter concerns the swelling effect of the staves on the bands. Do the manufacturers take this into consideration in designing bands or not?

Mr. Ledoux also brings to our attention the fact that the effect of water hammer is an ever present problem.

An elementary consideration of water hammer may lead to a better understanding of the more complicated investigations.

Water hammer may be explained with some degree of clearness by the analogy between the resilience in a bar of steel under pressure and a column of water in a penstock.

It can be seen that the amount of work done in stressing a bar is

$$K = 1/2\,Pe$$

also $P = aS$ and $e = Sl/e$

Therefore $K = 1/2\,S^2/E\,al$ (1)

where $P$ = total stress

$e$ = elongation

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[1] Journal, July, 1922, page 549.

$a$ = cross section area
$S$ = unit stress
$l$ = length

This represents the work stored within the body.

Now in the penstock there is a column of water having a certain amount of work stored up in it, equal to

$$K = \tfrac{1}{2}\frac{Wv^2}{g} = \tfrac{1}{2}\frac{walv^2}{g} \tag{2}$$

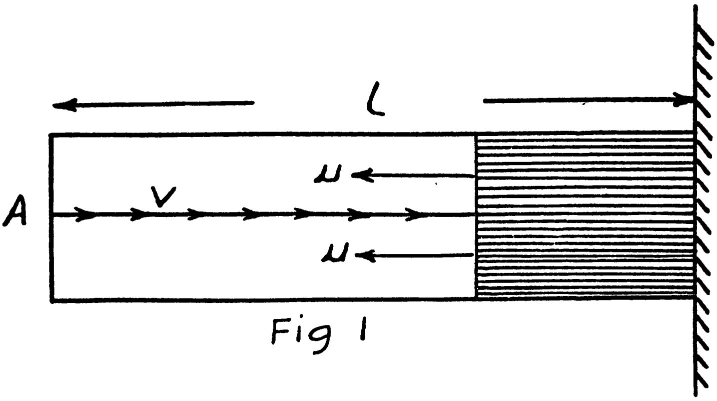

Fig 1

Equating (1) and (2) we have

$$S = v\frac{Ew}{g} \tag{3}$$

This represents the dynamic unit pressure produced by the retardation of the velocity, where $E$ equals modulus of elasticity of the water, usually taken at 294,000 pounds per sq. in.

It is better to express the value of $E$ in terms of the velocity of water hammer waves.

$$u = \sqrt{\frac{Eg}{w}}$$

To establish this formula we again use as a comparison a steel bar. In figure 1 the bar of steel is assumed to have struck the wall as shown and immediately there starts a wave of retardation of the molecules toward the end A as indicated by the arrows. When the wave has reached the end A the bar has been shortened an amount

$$e = vt \tag{4}$$

$e$ = total shortening.

Again there is set up in the bar a stress energy as previously shown equivalent to

$$K = \tfrac{1}{2} \frac{S^2}{E} al \tag{5}$$

From (4) we obtain the unit shortening

$$r = \frac{vt}{l}$$

as $E = \dfrac{S}{r}$ $\qquad r = \dfrac{S}{E}$

Substituting in (5) we have

$$K = 1/2\ E\ r^2\ \mathrm{al}$$

then substituting the value of $r$ we obtain

$$K = \tfrac{1}{2} E \frac{v^2 t^2}{l} a \tag{6}$$

Equating this to the kinetic energy of the bar (5) we have

$$\frac{wl}{g} = \frac{Et^2}{l} \quad \text{or} \quad \frac{l^2}{t^2} = \frac{\mathrm{Eg}}{\mathrm{w}}$$

But $\dfrac{l^2}{t^2} = u^2$ so that $\mathrm{u}^2 = \dfrac{Eg}{w}$

where $u$ represents the wave velocity

$$\text{or } u = \sqrt{\frac{Eg}{w}} \quad \text{or} \quad E = \frac{u^2 w}{g}$$

This value of $E$ may be substituted in (3) and by using a value of 4670 for $u$ and dividing $w$ by 144 to obtain proper units the formula may be further reduced.

$$S = \frac{wu}{g} v$$

This represents the dynamic unit pressure due to retardation. To estimate the excess of water hammer pressure over the static pressure, it is necessary to take into consideration the initial and final pressures.

Then $$S = Z + h - p$$

where $Z$ = excess water hammer
$h$ = static pressure, no flow
$p$ = initial dynamic pressure, water flowing.

Solving for Z and substituting above value of $S$ we have

$$Z = \frac{wu}{g} v + p - h$$

This does not take into consideration the energy expended in stretching the metal but is on the safe side since it gives a larger value for water hammer.

HARRY S. PAYROW.[2]

## BROM THYMOL BLUE AND PHENOL RED COLOR STANDARDS DO NOT DETERIORATE VERY RAPIDLY

It is the opinion of many who use color standards for the determination of hydrogen ions that the standards deteriorate very rapidly. This has been our experience with some indicators, but others seem to be more permanent. The laboratory at the Montebello Filters, Baltimore City Water Department, is in possession of some of the tubes of a set of brom thymol blue and phenol red standards prepared for Wolman by Miss Lillian Burroughs of the Maryland State Department of Health, in May 1920; and others of the same indicators prepared by the LaMotte Chemical Products Co. in July 1921. These tubes have been kept in a dark room all the time, except for a few minutes each day when in use. They were replaced by other standards after about 6 months use, and since then have been stored in a dark room. The following tables should be of interest:

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[2] Assistant Professor of Civil Engineering, Lehigh University, Bethlehem, Pa.

*Table showing the comparison of color standards with standards newly prepared*

| NEW STANDARDS PREPARED JULY, 1922 | LA MOTTE STANDARDS, PURCHASED JULY, 1921 | MARYLAND STATE DEPT. OF HEALTH, PREPARED MAY, 1920 |
|---|---|---|
| | Brom thymol blue | |
| 6.0 | 6.0 | Faded |
| 6.2 | Broken | 6.0 |
| 6.4 | 6.4 | Broken |
| 6.6 | Broken | 6.4 |
| 6.8 | 6.8 | 6.7 |
| 7.0 | 7.2 | 6.8 |
| 7.2 | 7.2 | 7.0 |
| 7.4 | 7.3 | 7.2 |
| 7.6 | 7.4 | 7.2 |
| | Phenol red | |
| 7.0 | Faded | |
| 7.2 | 7.2 | |
| 7.4 | Broken | Broken |
| 7.6 | 7.6 | 7.3 |
| 7.8 | 7.8 | 7.6 |
| 8.0 | 8.0 | 8.0 |
| 8.2 | 8.2 | 8.2 |
| 8.4 | 8.4 | 8.4 |

In some instances the color fades or changes to a different shade from that of new standards. This is more noticeable in the yellow color of the brom thymol blue standards. In such cases the standards are no good, but when the change is merely in pH value there is no objection to marking the true value and using them again.

JOHN R. BAYLIS.[3]

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[3] Principal Sanitary Chemist, Baltimore City Water Department.